

Claims

What is claimed is:

Claim 1. A method of horizontally structured CAD/CAM manufacturing for alternate operations, comprising:

selecting a blank for machining into an actual part;

establishing a coordinate system;

5 creating a master process model comprising:

a virtual blank corresponding to said blank;

a manufacturing feature;

virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship

10 with said coordinate system;

generating machining instructions to create said actual part by machining said manufacturing feature into said blank;

generating an alternate master process model comprising:

an extracted 3-D model from said master process model;

15 a manufacturing feature for alternate operations;

virtual machining of said manufacturing feature for alternate operations into said extracted 3-D model;

said manufacturing feature for alternate operations exhibiting another associative relationship with said coordinate system;

20 said generating said alternate master process model following said virtual machining of said master process model;

generating machining instructions to create said actual part by machining said manufacturing feature for alternate operations into said blank.

25 Claim 2. The method of Claim 1 wherein said associative relationship is a parent/child relationship.

Claim 3. The method of Claim 1 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 4. The method of Claim 3 wherein said associative relationship is a parent/child relationship.

Claim 5. The method of Claim 1 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 6. The method of Claim 5 wherein said associative relationship is a parent/child relationship.

Claim 7. The method of Claim 1 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 8. The method of Claim 7 wherein said associative relationship is a parent/child relationship.

Claim 9. The method of Claim 1 further comprising creating extracts from said master process model.

Claim 10. The method of Claim 9 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 11. The method of Claim 9 wherein said extracts exhibit an associative relationship with said master process model.

Claim 12. The method of Claim 9 wherein said associative relationship is a parent/child relationship.

Claim 13. The method of Claim 9 wherein said extracts are used to generate manufacturing process sheets.

Claim 14. The method of Claim 1 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 15. The method of Claim 14 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 16. The method of Claim 15 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 17. The method of Claim 1 wherein establishing said coordinate system comprises one or more datum planes.

Claim 18. The method of Claim 1 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a reference;

5 creating a second datum plane positioned and oriented relative to said reference; and

creating a third datum plane positioned and oriented relative to said reference.

Claim 19. The method of Claim 18 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 20. The method of Claim 1 wherein said manufacturing instructions comprise process sheets.

Claim 21. The method of Claim 20 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 22 The method of Claim 1 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 23. The method of Claim 1 wherein said another associative relationship is a parent/child relationship.

Claim 24. The method of Claim 1 further including said manufacturing feature for alternate operations exhibiting an associative relationship with said manufacturing feature.

Claim 25. The method of Claim 24 wherein said associative relationship is a parent/child relationship.

Claim 26. The method of Claim 1 wherein said virtual blank exhibits an associative relationship with said manufacturing feature for alternate operations.

Claim 27. The method of Claim 26 wherein said associative relationship is a parent/child relationship.

Claim 28. The method of Claim 1 further comprising creating alternate extracts from said alternate master process model.

Claim 29. The method of Claim 28 wherein said alternate extracts comprise replicated models of said alternate master process model at various operations of said manufacturing.

Claim 30. The method of Claim 28 wherein said alternate extracts are used to generate manufacturing alternate process sheets.

Claim 31. A method of horizontally structured CAD/CAM manufacturing for large parts, comprising:

- selecting a blank for machining into an actual part;
- establishing a coordinate system;
- 5 creating a master process model comprising:
 - a virtual blank corresponding to said blank;
 - a manufacturing feature;
 - virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative
- 10 relationship with said coordinate system;
 - generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
 - generating a junior master process model in a separate file than that of said master process model, comprising;
- 15 a 3-D model generated from said master process model;
 - a subsequent manufacturing feature;
 - virtual machining of said subsequent manufacturing feature into said 3-D model;
 - said subsequent manufacturing feature exhibiting another
- 20 associative relationship with said coordinate system; and
 - generating machining instructions to create said actual part by machining said subsequent manufacturing feature into said blank.

Claim 32. The method of Claim 31 wherein said associative relationship is a parent/child relationship.

Claim 33. The method of Claim 31 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 34. The method of Claim 33 wherein said associative relationship is a parent/child relationship.

Claim 44. The method of Claim 31 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 45. The method of Claim 44 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 46. The method of Claim 45 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 47. The method of Claim 31 wherein establishing said coordinate system comprises one or more datum planes.

Claim 48. The method of Claim 31 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a reference;

5 creating a second datum plane positioned and oriented relative to said reference; and

creating a third datum plane positioned and oriented relative to said reference.

Claim 49. The method of Claim 48 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 50. The method of Claim 31 wherein said manufacturing instructions comprise process sheets.

Claim 51. The method of Claim 50 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 52. The method of Claim 31 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 53. The method of Claim 31 further including modifying a link among a plurality of modeling elements.

Claim 54. The method of Claim 53 wherein said link comprises an associative relationship.

Claim 55. The method of Claim 54 wherein said associative relationship is a parent/child relationship.

Claim 56. The method of Claim 53 wherein said modifying comprises removing said link among said modeling elements.

Claim 57. The method of Claim 53 wherein said modifying comprises establishing said link among said modeling elements.

Claim 58. The method of Claim 53 wherein said modifying links among modeling elements includes substituting a second plurality of modeling elements for said plurality of modeling elements.

Claim 59. The method of Claim 31 wherein said another associative relationship is a parent/child relationship.

Claim 60. The method of Claim 31 further including said subsequent manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 61. The method of Claim 60 wherein said associative relationship is a parent/child relationship.

Claim 62. The method of Claim 31 wherein said virtual blank exhibits an associative relationship with said subsequent manufacturing feature.

Claim 63. The method of Claim 62 wherein said associative

Claim 64. The method of Claim 31 further comprising

Claim 65. The method of Claim 64 wherein said extracts

Claim 66. The method of Claim 64 wherein said extracts are

Claim 67. The method of Claim 31 wherein said junior

Claim 68. A method of horizontally structured CAD/CAM manufacturing for a plurality of charted parts, the method comprising:

selecting a blank for machining into an actual part:

establishing a coordinate system;

5 creating a master process model comprising:

a virtual blank corresponding to said blank;

a manufacturing feature;

virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship
10 with said coordinate system;

generating machining instructions to create said actual part by machining said manufacturing feature into said blank;

said master process model including, as said manufacturing features, those said manufacturing features common to said plurality of charted
15 parts;

generating a subsequent master process model comprising;

another virtual blank

a copy of said manufacturing features of said master process model;

20 a manufacturing feature uncommon to said plurality of charted parts;

virtual machining of said manufacturing feature which is uncommon to said plurality of charted parts into said another virtual blank;

said manufacturing feature which is uncommon to said plurality of charted parts exhibiting another associative relationship with said
25 coordinate system; and

generating machining instructions to create said actual part by machining said manufacturing feature common and uncommon to said plurality of charted parts into said blank.

Claim 69. The method of Claim 68 wherein said associative relationship is a parent/child relationship.

Claim 70. The method of Claim 68 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 71. The method of Claim 70 wherein said associative relationship is a parent/child relationship.

Claim 72. The method of Claim 68 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 73. The method of Claim 72 wherein said associative relationship is a parent/child relationship.

Claim 74. The method of Claim 68 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 75. The method of Claim 74 wherein said associative relationship is a parent/child relationship.

Claim 76. The method of Claim 68 further comprising creating extracts from said master process model.

Claim 77. The method of Claim 76 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 78. The method of Claim 76 wherein said extracts exhibit an associative relationship with said master process model.

Claim 79. The method of Claim 76 wherein said associative relationship is a parent/child relationship.

Claim 80. The method of Claim 76 wherein said extracts are used to generate manufacturing process sheets.

Claim 81. The method of Claim 68 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 82. The method of Claim 81 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 83. The method of Claim 82 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 84. The method of Claim 68 wherein establishing said coordinate system comprises one or more datum planes.

Claim 85. The method of Claim 68 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a reference;

5 creating a second datum plane positioned and oriented relative to said reference; and

creating a third datum plane positioned and oriented relative to said reference.

Claim 86. The method of Claim 85 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 87. The method of Claim 68 wherein said manufacturing instructions comprise process sheets.

Claim 88. The method of Claim 87 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 89. The method of Claim 68 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 90. The method of Claim 68 further including modifying a link among a plurality of modeling elements.

Claim 91. The method of Claim 90 wherein said link comprises an associative relationship.

Claim 92. The method of Claim 91 wherein said associative relationship is a parent/child relationship.

Claim 93. The method of Claim 90 wherein said modifying comprises removing said link among said modeling elements.

Claim 94. The method of Claim 90 wherein said modifying comprises establishing said link among said modeling elements.

Claim 95. The method of Claim 90 wherein said modifying links among modeling elements includes substituting a second plurality of modeling elements for said plurality of modeling elements.

Claim 96. The method of Claim 68 wherein said another associative relationship is a parent/child relationship.

Claim 97. The method of Claim 68 further including said manufacturing feature uncommon to said plurality of charted parts exhibiting an associative relationship with another of said manufacturing feature.

Claim 98. The method of Claim 97 wherein said associative relationship is a parent/child relationship.

Claim 107. The method of Claim 105 wherein said extracts are used to generate manufacturing process sheets.

- Claim 108. A manufactured part created by a method of horizontally structured CAD/CAM manufacturing with alternate manufacturing operations, comprising:
- a blank for machining into said manufactured part;
 - 5 a coordinate system;
 - a master process model comprising:
 - a virtual blank corresponding to said blank;
 - a manufacturing feature wherein said manufacturing feature is characterized by virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;
 - 10 said actual part created by machining said manufacturing feature into said blank in accordance with a machining instruction.
 - an alternate master process model comprising:
 - 15 an extracted 3-D model from said master process model;
 - a manufacturing feature for alternate operations;
 - virtual machining of said manufacturing feature for alternate operations into said extracted 3-D model;
 - said manufacturing feature for alternate operations
 - 20 exhibiting another associative relationship with said coordinate system;
 - said generation of said alternate master process model following said virtual machining of said master process model; and
 - said actual part created by machining said manufacturing feature for alternate operations into said blank in accordance with a machining
 - 25 instruction.

Claim 109. The manufactured part of Claim 108 wherein said another associative relationship is a parent/child relationship.

Claim 110. The manufactured part of Claim 108 further including said manufacturing feature for alternate operations exhibiting an associative relationship with manufacturing feature.

Claim 111. The manufactured part of Claim 110 wherein said associative relationship is a parent/child relationship.

Claim 112. The manufactured part of Claim 108 wherein said virtual blank exhibits an associative relationship with said manufacturing feature for alternate operations.

Claim 113. The manufactured part of Claim 112 wherein said associative relationship is a parent/child relationship.

Claim 114. The manufactured part of Claim 108 further comprising alternate extracts created from said alternate master process model.

Claim 115. The manufactured part of Claim 114 wherein said alternate extracts comprise replicated models of said alternate master process model at various operations of said manufacturing.

Claim 116. The manufactured part of Claim 115 wherein said alternate extracts are used to generate manufacturing alternate process sheets.

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Claim 117. A manufactured part created by a method of horizontally structured CAD/CAM manufacturing for large parts, comprising:

a blank for machining into said manufactured part:

a coordinate system;

5 a master process model comprising:

a virtual blank corresponding to said blank;

a manufacturing feature wherein said manufacturing feature is characterized by virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;

10 said actual part created by machining said manufacturing feature into said blank in accordance with a machining instruction.

a junior master process model in a separate file than that of said master process model, comprising;

15 a 3-D model generated from said master process model;

a subsequent manufacturing feature modeled by virtual machining of said subsequent manufacturing feature into said 3-D model;

said subsequent manufacturing feature exhibiting another associative relationship with said coordinate system; and

20 said actual part created by machining said subsequent manufacturing feature into said blank in accordance with a machining instruction.

Claim 118. The manufactured part of Claim 117 wherein said another associative relationship is a parent/child relationship.

Claim 119. The manufactured part of Claim 117 further including a subsequent manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 120. The manufactured part of Claim 119 wherein said associative relationship is a parent/child relationship.

Claim 121. The manufactured part of Claim 117 wherein said virtual blank exhibits an associative relationship with said subsequent manufacturing feature.

Claim 122. The manufactured part of Claim 121 wherein said associative relationship is a parent/child relationship.

Claim 123. The manufactured part of Claim 117 further comprising an extract created from said junior master process model.

Claim 124. The manufactured part of Claim 123 wherein said extracts comprise replicated models of said junior master process model at various operations of said manufacturing.

Claim 125. The manufactured part of Claim 123 wherein said extracts are used to generate manufacturing process sheets.

Claim 126. The manufactured part of Claim 117 wherein said junior master process model is generated following the machining of said master process model.

Claim 127. A manufactured part created by a method of horizontally structured CAD/CAM manufacturing for a plurality of charted parts, comprising:

- 5 a blank for machining into said manufactured part;
- a coordinate system;
- a master process model comprising:
 - a virtual blank corresponding to said blank;
 - a manufacturing feature wherein said manufacturing feature is characterized by virtual machining of said manufacturing feature into
 - 10 said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;
 - said actual part created by machining said manufacturing feature into said blank in accordance with a machining instruction;
 - said master process model including, as said manufacturing
 - 15 features, those said manufacturing features common to said plurality of charted parts;
 - a subsequent master process model comprising:
 - another virtual blank including a copy of said manufacturing features of said master process model;
 - 20 a manufacturing feature uncommon to said plurality of charted parts modeled by virtual machining of said manufacturing feature which is uncommon to said plurality of charted parts into said another virtual blank;
 - said manufacturing feature which is uncommon to said plurality of charted parts exhibiting another associative relationship with said
 - 25 coordinate system; and
 - said actual part created by machining said manufacturing feature common and uncommon to said plurality of charted parts into said blank in accordance with a machining instruction.

Claim 128. The manufactured part of Claim 127 wherein said another associative relationship is a parent/child relationship.

Claim 129. The manufactured part of Claim 127 further including said manufacturing feature uncommon to said plurality of charted parts exhibiting an associative relationship with another of said manufacturing feature.

Claim 130. The manufactured part of Claim 129 wherein said associative relationship is a parent/child relationship.

Claim 131. The manufactured part of Claim 127 wherein said virtual blank exhibits an associative relationship with any other said manufacturing feature which is uncommon to said plurality of charted parts.

Claim 132. The manufactured part of Claim 131 wherein said associative relationship is a parent/child relationship.

Claim 133. The manufactured part of Claim 127 further including said manufacturing feature common to said plurality of charted parts exhibiting an associative relationship with another of said manufacturing feature.

Claim 134. The manufactured part of Claim 133 wherein said associative relationship is a parent/child relationship.

Claim 135. The manufactured part of Claim 127 wherein said virtual blank exhibits an associative relationship with any other said manufacturing feature which is common to said plurality of charted parts.

Claim 136. The manufactured part of Claim 135 wherein said associative relationship is a parent/child relationship.

Claim 137. The manufactured part of Claim 127 further comprising extracts created from said subsequent master process model.

Claim 138. The manufactured part of Claim 137 wherein said extracts comprise replicated models of said subsequent master process model at various operations of said manufacturing.

Claim 139. The manufactured part of Claim 137 wherein said extracts are used to generate manufacturing process sheets.

Claim 140. A storage medium encoded with a machine-readable computer program code for horizontally structured CAD/CAM manufacturing for alternate operations, said storage medium including instructions for causing a computer to implement a method comprising:

- 5 selecting a blank for machining into an actual part;
- establishing a coordinate system;
- creating a master process model comprising:
 - a virtual blank corresponding to said blank;
 - a manufacturing feature;
 - 10 virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;
 - generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
 - 15 generating an alternate master process model comprising:
 - an extracted 3-D model from said master process model;
 - a manufacturing feature for alternate operations;
 - virtual machining of said manufacturing feature for alternate operations into said extracted 3-D model;
 - 20 said manufacturing feature for alternate operations exhibiting another associative relationship with said coordinate system;
 - said generating said alternate master process model following said virtual machining of said master process model; and
 - generating machining instructions to create said actual part by
 - 25 machining said manufacturing feature for alternate operations into said blank.

Claim 141. A storage medium encoded with a machine-readable computer program code for horizontally structured CAD/CAM manufacturing for large parts, said storage medium including instructions for causing a computer to implement a method comprising:

- 5 selecting a blank for machining into an actual part;
 establishing a coordinate system;
 creating a master process model comprising:
 a virtual blank corresponding to said blank;
 a manufacturing feature;
- 10 virtual machining of said manufacturing feature into said
virtual blank, said manufacturing feature exhibiting an associative relationship
with said coordinate system;
 generating machining instructions to create said actual part by
 machining said manufacturing feature into said blank;
- 15 generating a junior master process model in a separate file than
that of said master process model, comprising:
 a 3-D model generated from said master process model;
 a subsequent manufacturing feature;
 virtual machining of said subsequent manufacturing
- 20 feature into said 3-D model;
 said subsequent manufacturing feature exhibiting another
associative relationship with said coordinate system; and
 generating machining instructions to create said actual part by
 machining said subsequent manufacturing feature into said blank.

Claim 142. A storage medium encoded with a machine-readable computer program code for horizontally structured CAD/CAM manufacturing for a plurality of charted parts, said storage medium including instructions for causing a computer to implement a method comprising:

- 5 selecting a blank for machining into an actual part;
 establishing a coordinate system;
 creating a master process model comprising:
 a virtual blank corresponding to said blank;
 a manufacturing feature;
10 virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;
 generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
15 said master process model including, as said manufacturing features, those said manufacturing features common to said plurality of charted parts;
 generating a subsequent master process model comprising:
 another virtual blank with a copy of said manufacturing
20 features of said master process model;
 a manufacturing feature uncommon to said plurality of charted parts;
 virtual machining of said manufacturing feature which is uncommon to said plurality of charted parts into said another virtual blank;
25 said manufacturing feature which is uncommon to said plurality of charted parts exhibiting another associative relationship with said coordinate system; and
 generating machining instructions to create said actual part by machining said manufacturing feature common and uncommon to said plurality
30 of charted parts into said blank.

Claim 143. A computer data signal for horizontally structured CAD/CAM manufacturing for alternate operations, said computer data signal comprising code configured to cause a processor to implement a method comprising:

- 5 selecting a blank for machining into an actual part;
 establishing a coordinate system;
 creating a master process model comprising:
 - a virtual blank corresponding to said blank;
 - a manufacturing feature;
- 10 virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;
 - generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
- 15 generating an alternate master process model comprising:
 - an extracted 3-D model from said master process model;
 - a manufacturing feature for alternate operations;
 - virtual machining of said manufacturing feature for alternate operations into said extracted 3-D model;
- 20 said manufacturing feature for alternate operations exhibiting another associative relationship with said coordinate system;
 - said generating said alternate master process model following said virtual machining of said master process model; and
 - generating machining instructions to create said actual part by
- 25 machining said manufacturing feature for alternate operations into said blank.

Claim 144. A computer data signal for horizontally structured CAD/CAM manufacturing for large parts, said computer data signal comprising code configured to cause a processor to implement a method comprising:

- 5 selecting a blank for machining into an actual part;
- establishing a coordinate system;
- creating a master process model comprising:
 - a virtual blank corresponding to said blank;
 - a manufacturing feature;
 - virtual machining of said manufacturing feature into said
- 10 virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system;
- generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
- generating a junior master process model in a separate file than
- 15 that of said master process model, comprising;
 - a 3-D model generated from said master process model;
 - a subsequent manufacturing feature;
 - virtual machining of said subsequent manufacturing
- feature into said 3-D model;
- 20 said subsequent manufacturing feature exhibiting another associative relationship with said coordinate system; and
- generating machining instructions to create said actual part by machining said subsequent manufacturing feature into said blank.

5 selecting a blank for machining into an actual part;
 establishing a coordinate system;
 creating a master process model comprising:
 a virtual blank corresponding to said blank;
 a manufacturing feature;
10 virtual machining of said manufacturing feature into said
virtual blank, said manufacturing feature exhibiting an associative relationship
with said coordinate system;
 generating machining instructions to create said actual part by
 machining said manufacturing feature into said blank;
15 said master process model including, as said manufacturing
features, those said manufacturing features common to said plurality of charted
parts;
 generating a subsequent master process model comprising;
 another virtual blank with a copy of said manufacturing
20 features of said master process model;
 a manufacturing feature uncommon to said plurality of
charted parts;
 virtual machining of said manufacturing feature which is
 uncommon to said plurality of charted parts into said another virtual blank;
25 said manufacturing feature which is uncommon to said
plurality of charted parts exhibiting another associative relationship with said
coordinate system; and
 generating machining instructions to create said actual part by
 machining said manufacturing feature common and uncommon to said plurality
30 of charted parts into said blank.